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THESIS

FACILITIES PLANNING FOR A MICRO-COMPUTER LABORATORY
FOR THE
ADMINISTRATIVE SCIENCES DEPARTMENT AT THE
NAVAL POSTGRADUATE SCHOOL

by

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March 1986

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At the Naval Postgraduate School, a microcomputer laboratory is needed, both to supplement the existing computer assets, and to provide the exposure to microcomputers the students must have to be effective as managers of the information systems for which they are responsible.

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This thesis performs the facilities planning for a microcomputer laboratory for the Administrative Sciences Department at the Naval Postgraduate School.

Facilities Planning for a Micro-computer Laboratory for the Administrative Sciences Department at the Naval Postgraduate School.

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ABSTRACT

As computers are being used to an increasing degree throughout the military services, there is a rising demand for computer arrangements which can take advantage of the power of microcomputers. The high cost of mainframe computers, the complex software they require, and the high cost of that software is making it more attractive to use a network arrangement of smaller computers to do many of the jobs of a single mainframe.

At the Naval Postgraduate School, a microcomputer laboratory is needed, both to supplement the existing computer assets, and to provide the exposure to microcomputers the students must have to be effective as managers of the information systems for which they are responsible.

This thesis performs the facilities planning for a microcomputer laboratory for the Administration Sciences Department at the Naval Postgraduate School.

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I. INTRODUCTION AND BACKGROUND

At the Naval Postgraduate School, the Administrative Sciences Department is the largest department and within this department, the Information Systems curriculum is the largest on campus.

There is an increasing number of computerized systems being used in military operations. Since the Information Systems curriculum at the Naval Postgraduate School (NPS) plays such an important role in the further education of an increasingly large and important group of the military's managerial force, it was decided that these students needed more exposure to the practical aspects of computer operation. Without this practical experience, the future managers of the military's information systems would be at a disadvantage both at the bargaining table, and at day to day management of the assets they are charged with.

Within the Information Systems curriculum, the courses of instruction were previously classroom oriented. This allowed little exposure or practical experience for the students on the hardware and software they would be managing when they left the Naval Postgraduate School.

Prior to 1982, the Administrative Sciences Department had to depend solely on the mainframe computer and on assets

used in other departments for all of its computer related instruction.

At that time, the Administrative Sciences Department converted two small rooms into a computer laboratory. By the time this laboratory was operational, it was already inadequate for the large, and growing, number of users. The facilities proved to be too limited in the number of workstations and were insufficient in providing all of the students with enough experience on the subjects they were studying in their classes.

To keep pace with evolving technologies it was imperative that the Information Systems curriculum include an increasing amount of instruction involving the use of microcomputers.

The Information Systems curriculum has barely been able to meet the instructional requirements with their existing computer facilities. Computing needs have been partially met by the students use of computing assets of other departments, on a time available basis. Using the assets of the other departments has been unreliable and often required the Administrative Sciences students return to the campus during the evening hours in order to find computers which were available.

To alleviate the problem of limited access to computers, the Chairman of the Administrative Sciences Department, Professor Greer, along with the Academic Associate,

Professor Schneidewind, planned for the initial phase of a larger microcomputer laboratory which, on completion, would meet the requirements of the Administrative Sciences Department and the Information Systems curriculum. Appendix A contains the Administrative Sciences Department laboratory justification and preliminary list of hardware components.

The proposed Administrative Sciences laboratory is to be housed in Ingersoll Hall in rooms I-249 and I-250 . A second laboratory, the Information Systems laboratory will be initially installed in Ingersoll Hall room I-158 and expanded later to rooms I-349 and I-350 in the same building.

Deciding that a facility is needed and actually implementing it are two different matters. Facilities planning of the laboratory area is an important first step.

II. PHYSICAL ASSETS

The conversion of classrooms into a microcomputer laboratory causes requirements for cooling, electricity and lighting to change. Constraining this change are the limits of the existing physical facilities and the project's budget. This section examines the compromises made in the shape of the facility, the services provided, and other facility issues.

A. SHAPE OF FACILITY

The space required for an individual at a computer workstation is considerably greater than that required for an individual at a conventional desk. This increase in space per student made it impossible to fit the twenty-five stations required for a class into any of the available classrooms.

Since the facility would not fit into a single classroom and two classrooms could not be eliminated, a classroom and an adjacent office/storeroom were allocated, rooms 249 and 250 of Ingersol Hall (see Figure 1). These rooms were located in a corner of the building, creating an L - shaped area for the laboratory. It also required the removal of the

wall dividing the two rooms and the electrical and telephone conduit which were installed in the wall.

After this work is completed cosmetic repairs will be required to make a smooth transition along the ceiling walls and floor of the new room. This is not too large a job since both rooms have a standard ceilling, wall and floor covering. Thus the repairs are basically a patch, using standard color ceiling and floor tiles and sheetrock on the affected wall areas.

Finally one of the new room's two doors will be permanently closed to reduce the amount of space wasted in the aisles.

This work completes the shell of the facility. The method of transforming this L - shaped facility into a suitable instructional facility will be discussed in Section IV.

B. NECESSARY SERVICES

Numerous "services" are required for an effective microcomputer laboratory facility. While these requirements are not at all on the same scale as the specialized electrical power and cooling requirements of a mainframe computer, some additional services are clearly required when compared to a conventional classroom. These areas include investigation of electrical power supply, room ventilation

and lighting to determine if existing facilities are sufficient.

1. Electrical Power Requirements

As shown in Appendix A, the peak power requirement for each workstation is between three and four amps of 115 volts AC, for a total of 100 amps. The wiring suplying the rooms will support this power requirement easily. The only problem is the requirement to distribute this power to each workstation, with three outlets each - for CPU, monitor and (optional) printer. Three basic geometries for power distribution are available: from above, from the side or from below.

The least acceptable alternative would be to attempt to supply the power to each station from below. The floors in this area of the building are asphalt tile on concrete slab. For a microcomputer lab the effort involved in cutting thrugh this material would be too time consuming and too expensive.

No commercial product was found that ran at floor level to carry the required cables and would provide adequate resistance to wear from student traffic and which would cross aisleways in a manner that would not cause students to trip and stumble. The base Public Works department also had no experience with installing or constructing such an installation.

The next method reviewed was to drop the wiring from the ceiling down to each computer or group of computers. This would take advantage of the fact that the existing wiring distribution in the building was in the space above each level's false ceiling. Wiring from above would hide most of the distribution network above the false ceiling, leaving only the section between the desk top and the ceiling in the open. However, that is precisely what is wrong with this plan; there would be obstructions to the student's view from the cables hanging in their line of sight. There is also concern for the strength of this cabling in the laboratory setting. Any attempt to strengthen these cables using conduit would further degrade the student's view. In addition to this major deficiency, we found no suitable commercial products and the Public Works department had no experience constructing this type of installation.

The third method of supplying electrical power is to approach each group of workstations from the side, originating at a wall. In this method the wiring is brought down from above the false ceiling at the wall and run at desk-top level along each group of workstations. The only drawback to this method is that each group of workstations must abut a room wall to allow access to the cabling. This drawback was not considered significant compared to those

associated with the other schemes. The ready availability of commercial products for supplying power at table top level and the experience which the Public Works department has in constructing this type of installation were the reasons that this method which was selected. By utilizing products commercially available, Public Works can customize the installation, ensuring that will fit the final laboratory arrangement and make future changes in arrangement much easier.

The final choice for providing electrical power was the conventional one: running along the desks from the wall in the manner similar to that which has been provided to office machines since they were first electricaly powered. This selection dictated the manner in which several other services would be provided.

2. <u>Network and Phone Connections</u>

Since all of the workstations were to be connected into a network, provisions were required which would allow coaxial cabling to be routed between units. A modem was desired for each workstation to allow the user to access the school's mainframe computer and other services, such as the Defense Data Network. This requires a telephone cable connection to each unit. These requirements could easily be fulfilled using the conduit which was prescribed for supplying electrical power to the units. This conduit has

sufficient room for the electrical wiring, several coaxial cables (to allow for various designs of network and room arrangements) and numerous phone cables.

3. Lighting

There are three common sources of lighting in an indoor setting: sunlight from windows, fluorescent light and incandescent light. In an ideally lighted setting all three sources play a role.

The ideal background light level in a working environment is 500 to 700 lux. This should be full spectrum sunlight, preferably reflected from a white surface to minimize harsh glare. This level and type of light is the least stressful to a workers eyes. For periods when this level of sunlight is unavailable it should be supplemented or replaced by fluorescent lighting.

Task lighting is the term used to describe the amount of light needed in a particular location for a particular task. The most common type of task lighting is that required for reading and other work requiring high visual clarity. This is best achieved by using an overhead incandescent spot light on the work surface to obtain a level of about 800 to 900 lux.

Task lighting for work with a CRT should be lower than the general working environment, about 300 to 500 lux, and should come from incandescent bulbs or sunlight.

Fluorescent lighting should be minimized in the area of CRTs because of its' cyclical nature. This flickering added to that which comes from the CRT is an additional source of eyestrain.

Thus the ideal microcomputer lab would have a sunlit background supplemented by fluorescent lights to a level of 500 to 700 lux. Each workstation would have a task lighted spot of 800 to 900 lux for reading and a darker area of 300 to 500 lux for terminal work where fluorescent lighting was minimized.

The rooms allotted for the laboratory clearly made this ideal lighting scheme impractical. Both rooms were initially lighted to a standard classroom level of apout 800 lux by fluorscent lights. There were no windows in either room. To accomodate the required 25 workstations (24 students, 1 instructor) only relatively small spaces could be allotted to each workstation. These small spaces did not allow for the various levels of light intensity which the ideal plan called for.

Since there were no windows for sunlight the existing fluorescent lighting would be the sole source of background lighting. The small space alloted to both the reading and terminal "task areas" meant that both would be at the same light level. Since this was an instructional area, note taking and reading of documentation was felt to

be of greater importance than minimizing eyestrain from the CRT. This dictated a light level similar to that already existing in the room, the 800 lux "reading" level. Since the research on eyestrain associated with high levels of fluorescent light and CRTs was based on full working days at the terminal, the effect on students in class for one or two hours was felt to be acceptable.

Thus the only changes required to the existing lighting were to consolidate all of the switches at a single location for conveinence and to allow for turning out about one half of the lights for use of a large screen projector . This would also reduce the light level to the range desired for long term CRT work.

4. Ventilation

In the classroom, as in the office, workers require climate control to function efficiently.

In room design there are three phases of ventilation which must be considered:

- Outdoor air (Necessary fresh air per occupant)
- Heat loss (Requiring heating)
- Heat gain (Requiring cooling)

The only one of these aspects which is affected by the changes being made to the rooms will be the increase in heat gain from the additional electrical equipment. Outdoor air requirements will be smaller since the number of people

using the rooms at one time will decrease due to the larger size of computer workstations. Heat loss will be unaffected because there are to be no changes to the outer walls.

Because of the temperate climate in the Monterey area, the design of the classrooms in Ingersol Hall were initally constrained by the outdoor air requirement. The two rooms combined have an air flow of 940 cubic feet per minute (cfm) to meet this climatic requirement.

Calculations were made to ensure that the additional heat load did not require additional ventilation, making heat gain the dominant aspect of ventilation. These calculations (shown in Appendix B) indicate that the three major contributors to room heating (lighting, people and the computers) do not require more than the existing amount of ventilation. They also confirm the validity of a rule of thumb which states that each computer workstation contributes about as much to room heating as a student engaged in typical classroom activity.

In summary, the increased ventilation from the combination of the two rooms and the decreased number of students due to size of workstations offset the addition of the heat producing computers. This resulted in the existing ventilation being sufficient for the new use of the rooms.

C. OTHER PHYSICAL FACITITY ISSUES

The addition of the microcomputers and peripherals to the classroom environment raises questions about other aspects of the facility such as dust control and noise pollution.

The typical classroom is a dusty environment, primarily due to the chalkboard. While microcomputers do not require an antiseptic environment, they do have an internal, fan-driven ventilation system which draws room air through them. This can cause the interior of the unit to become fouled if it is operated in a dusty environment. Two actions were taken to reduce the dust level to a practical level.

First the chalk boards were to be removed and replaced with "white boards." These boards utilize alcohol based markers on a white background. The marking is erased using a cloth and water. This method greatly reduces the primary source of dust and the boards have the added benefit of serving as a screen for a large screen projector, eliminating the need for an additional piece of equipment.

Second, the floors were specified to remain covered with asphalt tile rather than being carpeted as many of the classrooms in the school. Carpeting tends to retain dust and vacuuming raises a great deal of it into the air.

These two measures were considered to be sufficient for dust control. Since the facility has direct access from the hallway, filtered ventilation was not considered to be a cost-effective option since this would have forced a rebalancing of the ventilation system for the entire building.

The microcomputers themselves create high frequency noise from their internal fans. This is generally in the range of 60 dB. At this level, long term exposure results in mild annoyance. A similar noise level results from non-impact type printers such as ink jet or laser printers. Thus these devices, while adding to the general noise level, cause no great complication.

Impact type printers, such as dot matrix or daisy wheel, create high noise levels, generally from 70 to 90 dB. The more recently manufactured models have shown consideration to the noise issue and are generally in the lower end of this spectrum. At these levels the noise created would be disruptive to a lecture and has been shown to cause irritability from prolonged [> 1 hour] exposure. [Ref. 1: p. 399]. Current government standards for a work place dictate 85 dB long term and 100 dB short term as the legal limits for noise. These far exceed what is tolerable in a lab setting.

Since noise attenuation shielding other than the installed acoustical ceiling tile is impractical for the limited space in the lab setting, the use of the planned laser printer as the primary printer was recommended.

D. REMARKS

A careful study of the ideal physical characteristics for a microcomputer lab painted a picture of spacious workstations with the correct electrical connections, various lighting for tasks, ample individual ventilation and a clean and noise-free environment. Working within a limited budget and considering the physical constraints imposed, a plan which required a minimum number of changes to the existing facilities and still fulfilled the basic physical needs for an effective instructional laboratory was developed.

III. INSTRUCTIONAL ENVIRONMENT

This laboratory will have several uses ranging from instructional to research.

To efficiently perform in these areas, the layout of the laboratory and the selection of workstations to be used should not be a radical departure from accepted standards in classroom design. While innovative approaches can be considered, the instructional environment should not be allowed to suffer just for the sake of 'something new.' The old adage--make it 'sailor proof'--can be applied here.

A. WORKSTATIONS

Design of the room layout hinged on the selection of the type of workstation to be used. Considerations included, first making permanent, table-top workstations by an independant contractor and secondly, purchasing prefabricated workstations from a vendor.

The single advantage of using built-in tables [more customized features in table design], was overriden by their disadvantages:

1. Once constructed, built-in tables to be used as workstations are permanent, allowing no future flexibility in workstation or classroom arrangements.

2. Depending on the contracts let for the construction of the built in tables, the costs would be as high if not higher than workstations purchased from a vendor.

3. The time required to complete construction by a contractor would require the classroom be unavailable for other uses for a longer period of time when compared to purchasing workstations. (Assuming the same amount of time required in either case for the installation of the wiring involved in workstation hookups.)

There are several workstations available on the market which would fulfill the requirements of the user, but an environment where many people are using the workstations imposes other restrictions. The heavy use stipulates that workstations be constructed in as simple a manner as possible to provide long service life. There should be no moving parts which would require maintenance or possibly become inoperative.

Tiered workstations exist where the cpu and monitor are on one level and the keyboard is on another level about four inches lower. While handy for some office applications, this arrangement will reduce the flexibility of the workstation should they be put to other uses.

Another type of workstation available is one which has a flat table top and makes use of a pull-out drawer which contains the keyboard. This workstation incurs high maintanance costs in keeping the pull-out trays in operating condition. If they should be bumped by people going down the aisle, with the keyboard left extended,

damage would result. They are designed more for office work, and purchasing them for this environment would be a mistake. Another drawback is that the user has to adjust his seating when he pulls out the drawer containing the keyboard. This reduces the aisle space.

The optimum workstation was determined to be a flat table top design with dimensions of 36 inches wide by 30 inches deep, and a standard keyboard height of 26.5 inches. A 36 inch width was selected for several reasons: anything less than 36 inches wide allowed no space for additional material, such as notes, at the workstation; anything wider reduced the number of workstations which could be placed in the laboratory; and it was one of the standard widths manufacturers supply for computer workstations. The selected depth of 30 inches was also a standard size among manufacturers and anything less than that left little room for both a cpu and a keyboard on the table top.

B. CPU MOUNTING

After selection of the tables, consideration must be given to how computer components are going to be placed on the workstation.

The standard arrangement is to have the monitor sit on top of the cpu with the keyboard located directly ahead of the user.

In an office it is sometimes advantageous to have the monitor on a moveable arm so the user can see the monitor from several locations. In our case the user will access the computer from one location only, so that capablility is neither needed nor desired. Having the monitor moveable gives no appreciable advantage and the moveable arm is just one more item to fail under long term usage. Monitors could get bumped and fall off these movable arms should the monitor be placed over an aisle. Just as important, though, placing the monitor on a moveable arm complicates the security problem of tieing all the components of one computer together.

There are accessories which allow for vertical mounting of the cpu. Vertical mounting of each cpu would free up desk space for the user but there are problems:

1. The configurations investigated didn't have a vertical mounting system which was a permanent fixture on the side of the workstation, but rather were simply units sitting on the floor which held the cpu in a vertical position.

2. The danger of dust getting into the cpu is great. With open disk drives, at ankle level, the question is not 'if' dust will get into the computer but 'how much.'

3. With the cpu at floor level, in a highly trafficked area, damage to the element is a high probability due to being inadvertantly kicked by the users.

4. If the computers have hard disks, other problems arise. Discussions with the service department of a major computer manufacturer [Ref. 2] revealed that except for two specific models, any mounting of a cpu in other than the horizontal position would void the warranty. The internal wire harness of their hard disks is not designed to withstand the forces at other than the design

attitudes. If a hard disk is operating (assuming one is purchased which can operate vertically) and it is inadvertantly bumped by someone's foot, the gyroscopic effect of the rapidly spinning hard disk will cause damage requireing replacement, or at the very least, extensive maintenance.

The disadvantages of vertical hard disk mounting outweigh the advantage of freeing up workspace.

C. ROOM ARRANGEMENT

As discussed in the section 'Physical Assets', the requirement that the classroom be able to support at least 24 workstations necessitated the removal of the wall between rooms I-249 and I-250. Figures 2 and 3 show unsuccessful attempts at laying out the laboratory using a single room and having an adjacent room contain peripheral equipment. It became apparent that the laboratory would be better constructed if the wall between the two rooms was removed. The room resulting from the combination of these two rooms posed some problems in planning the layout of the laboratory. Using the workstation desks recommended above, fitting in 24 workstations, printers, and allowing for adequate storage, forced additional restrictions using the 'L' shaped room.

Space was at a premium. One source of additional space for workstations was to minimizing aisle space. References 3 and 4 state that the aisles should be at least 30 inches

wide [desk to desk, and not including chairs]. Anything less than 30 inches impedes movement of personnel in the aisles. This 30 inch spacing between rows of workstations became a fixed value which was then used in all trial room arrangements.

Early in the design of the room arrangement, it was decided that storage for software, paper and other supplies would be placed along the northwest wall, and the printer placed in the same area. This decision was based on minimizing space lost due to the shape of the room, the existance of shelving already along that wall, and because of electrical power availability.

An initial room arrangement is shown in Figure 4. In this arrangement, although the required number of workstations was met, the space available for storage and locations of the peripheral equipment was scattered around the room. Part of the problem resulted in an excessively wide aisle running down the side of the room, the aisle was 5.5 feet wide. The instructor's podium was at the wall opposite the door, the printer was at the rear of the room, while storage was along the northeast wall. This layout is unsatisfactory for three reasons:

1. limited space for additional components when compared to other room arrangements,

2. excessive wasted space in wide aisles.

3. students sitting at the ends of the front row would be viewing the front of the class at an acute angle, making viewing more difficult.

Figure 5 represents essentially the same arrangement except that the instructor is located at the other end of the classroom and the workstations are turned around facing the other direction. For the instructor to utilize a 'white board' and a large screen projector, existing shelving at the front of the classroom would have to be removed, only to be reinstalled at some other place in the laboratory. In addition, space for additional components is still limited.

In Figure 6 the arrangement will support the required number of workstations. Its major drawback is that due to the length of the front row and its proximity with the front wall, students sitting at the ends of the front row will have trouble seeing a large screen projector or a 'white board' due to the acute viewing angle.

The classroom arrangement as shown in Figure 7 was an attempt at trying something innovative and the results were deemed totally unsatisfactory for several reasons:

1. This arrangement didn't allow for the required number of workstations.

2. Due to the angled relationship between the walls and the workstations, there was an excessive amount of wasted space.

3. In this arrangement, routing power to the components becomes difficult. Instead of routing power along the

walls and branching down the rows of workstations, the power now would either have to be run to the workstations along the floor, up through the floor, or be dropped through the ceiling. In either case, the installation becomes more complex with no benefits as a result.

Other configurations were investigated where the desks were placed at other angles, with respect to the walls, with much the same result. In all cases the required number of workstations wouldn't fit into the space provided, getting power to the units became a problem and again, there were no benefits. Attempts to align the workstations in other than traditional arrangements were abandoned.

The most acceptable arrangement of workstations is shown in Figure 8. In this arrangement, the requirement of supporting 24 workstations is achieved, along with a number of other advantages.

1. The length of the front row is minimized so the viewing angle of any chalk board or large screen projector for the front row users is minimized.

2. All of the workstations can have electrical power routed to them with a minimum of modifications to the room.

3. A four foot long table at the ends of each of the two back rows is available for use as a desk to hold additional printers.

4. The aisles are adequate without taking an excessive amount of room.

5. The storage area is centralized and there is room in the area for later addition of more peripheral equipment; additionally, existing shelving can be utilized.

Figure 8 represents the recommended workstation arrangement.

D. STORAGE

Having adequate storage for all of the accessories which will become a part of this laboratory must be addressed for this laboratory to function smoothly.

Several types of storage containers were researched but few were really suitable for use in this environment. What was deemed necessary was a type of container which had individually lockable partitions to which the users could have access.

One section of the storage may contain applications software which would remain locked at all times. Those classes which are utilizing these particular programs would be given keys or the combination to that area of the storage area. When authorized users need access to these applications programs during other than normal hours, they would be able to continue work, rather than depend on staff being present to allow access to the material they need.

Finally, a region of the storage area could be devoted to hardware, such as modems, expansion chassis etc. This could be a technician's storage area, or almost any other storage which would require only limited access.

Access to the storage cabinets is discussed under 'SECURITY' and will not be further discussed here.

Sufficient storage exists in the form of shelving to hold incidental gear such as cleaning gear, paper, and

other items needed on a routine basis in the operation of the laboratory.

E. MISCELLANEOUS

Other considerations in the planning of the laboratory arrangement are the placement and selection of miscellaneous equipment.

1. Chalk Boards

As discussed previously, conventional chalk boards are unsuitable in a computer environment due to the resulting chalk dust generated. Other laboratories have been established utilizing conventional chalk boards and have had significant maintenance problems. The best substitute for these boards are the 'white board' variety which use 'liquid chalk'. While residue is not completely eliminated, it is significantly reduced and, since there will be only one workstation within 3 feet [the instructor station] of the chalk board, the problem with airborne particulate will be minimized.

Using the 'white board' does have a particular side effect though. There is static electricity associated with its use, which is not present with the conventional chalk board. This is not expected to be a problem.

2. Large Screen Projector

A large screen projection capability is desirable for a labratory of this kind. This will enable the entire class to observe what the instructor is demonstrating, rather than have the students cluster around a single display.

Two methods of projection were investigated for implementation. The first was a type of reverse projector which would be located in an adjoining room and project onto a special screen between the two rooms. The problem with this type of projector is that it often takes a projectionist to operate it since the projector and instructor are in two different rooms, but more important, is the large space requirement. A system which would project an image large enough to be practical would require a distance of at least another entire room to expand the beam onto the screen. This would require too much space.

The second type of projector is one which would be contained in the classroom and project onto a conventional screen at the front of the room, or more simply, utilize one of the two 'white boards' as a screen. Using the room arrangement recommended, two options exist for installation of such a large screen projector. If desired, one of the workstations could be removed in the center of the room and replaced with the projection unit.

The second option is to mount the unit from the ceiling. The best alternative depends on the type, size and control mechanism of the projector purchased.

Since the laboratory will have 'white boards' instead of chalk boards, no additional screen is necessary, as the 'white boards' can be utilized as a screen.

3. Chairs

There are no special requirements for the selection of chairs for the laboratory. Those comparable with others currently in use in campus classrooms are all that is required.

4. Carpets

Due to their nature, carpets generate static electricity and should not be used in any part of the laboratory. The subject of carpets is further-discussed in the section on Physical Assets.

IV. MISCELLANEOUS EQUIPMENT

The smooth operation of a micro-computer laboratory depends on more than just the physical arrangement of a group of computers in a room. While this may be enough to get the occasional user started on a project, it can be the incidentals which make the difference between a productive environment and one which is merely operational.

Some of these 'incidentals' are important not just to productivity, but also to protecting the assets of the laboratory. These include having each workstation being supplied electrical power via a surge protection device. While the electrical power supplied to the room is regulated by the power company, it is important that every workstation be protected by such a device. If not, and a voltage surge should occur due to line fluctuations or an electrical storm, the loss value of damaged equipment could be much more than the additional investment in protection devices.

In addition to surge protection devices, there are other items necessary for the operation of the laboratory. The following partial list is supplied:

1. The laboratory should have a large trash container suitable for holding the oversize sheets of paper and the large quantities of paper which may accumulate at the printer stations. A proper size container would be of about 36 gallon capacity.

2. For a room the size of the laboratory, and considering the paper usage, two smaller trash containers of the type currently in other classrooms on campus should be included.

3. To minimize loss of data and to protect both purchased and locally developed software, containers for 'floppy disks' should be purchased. For a room of this size, there should be five of these diskette holders. This will allow for better control of programs and data made available to the laboratory users. Diskettes containing commonly used programs could be available to all users, while some applications programs could be made available to only selected users.

Other consumable items (such as printer paper, printer ribbons, and chalk markers) will be used in the laboratory. Their use is not unique to this laboratory and are needed for the operation of any classroom on campus which utilizes chalkboards and printers.

These should be ordered through normal supply channels and since they are classified as consumables, are not considered important in the facilities planning of the laboratory.

V. SECURITY

Implementing a form of security in a computer system can have several aspects. These range from protecting classified material and other privileged information to that of physical security of the system components.

A. CLASSIFIED MATERIAL

At the Naval Postgraduate School the Administrative Sciences Department does not routinely handle classified information. Although there currently is no requirement for the processing of classified data in the laboratory, it was considered in the facilities planning to provide more flexiblity for future use of the computing assets.

The room to contain the proposed laboratory has some advantages. It is contained in a building which can be locked and the building located on a compound patrolled by a security force. The room has no windows, doors will have combination locks, and access will be limited. Should the facility be required to process classified information, it could be relatively inexpensive to certify it when the requirement arises. Reference 5 defines the requirements for such certification.

Currently there is no classified material involved in any of the Information System classes. There are other facilities on campus certified for this, so the subject of upgrading the security standing of this laboratory was not considered further.

B. PHYSICAL SECURITY

1. Room Access

The physical assets of the laboratory will amount to a sizeable investment by the Administrative Sciences Department.

Although, as discussed above, the laboratory will be located inside a building which can be locked and is regularly patrolled by base security, extra precautions should be taken to guard against theft of equipment.

Access to the laboratory will be limited to one door. Although two doors currently allow access, one door will be blocked off, and the other door will have a combination type lock to control access. With the large number of people who will have access to the laboratory, control of the combination could be a problem. Although limiting access to the facility will increase security, it will also make the assets unuseable if taken to an extreme.

Consistent with the current policy of the Administrative Sciences Department, the combination to the

laboratory will be controlled by the department office. Only those students who have a need to use the facility will be given the combination, and a list will be kept of all those currently having access. Since the student population is constantly changing, the combination to the door should also be changed at periodic intervals.

The recommended type of lock to be placed on the door is the combination variety. The advantage of combination locks is that they allow for periodic changing of the combination as the user population changes.

A disadvantage of the combination lock though is that the combination could be passed verbally from a valid user to an unauthorized person. Over time, this could result in a loss of control of the list of authorized users.

With a key type lock, the principle of one key for one user is essentially valid but an authorized user could have another key made, and the scenario above would be repeated. To correct this loss of control would necessitate replacement of the locks and reissuing keys to all authorized users. This is an inconvenient process, to say nothing of the continued expense involved.

2. <u>Component Security</u>

Further security of physical components can be achieved by locking all individual components to more permanent fixtures within the laboratory.

Although any type of locking device can be defeated, given enough time and determination, research has shown that, if the prospective thief has to spend more than a couple minutes to free a component, he is likely to give up.

Several security devices for micro-computers are available on the market. These range from placing individual workstations inside lockable cabinets, to sophisticated motion sensors with integrated audio alarms which are mounted within the computer chassis. The size of the cabinets which would contain all of the components precluded their use in an instructional environment. Their protective scheme also depended on key type locks which would require components to be dedicated to individual users or open access to the keys. The first option unnecessarily restricts user access and the second almost eliminates the security sought for in the first place.

While a system with an audible alarm would be nice, there are several considerations which could preclude their use in some installations. For example, if the units were to be moved around regularly by students conducting research, then staff must be available to reset the attendant alarms. For use as intended by this installation, though, this will not be

a problem since the computers will be connected in a network, making the physical location of the units in the room of no concern to the users. Except for temporary relocation of individual units for maintenance, or possibly being needed in another location on campus, [i.e., presentations or seminars], the movement of computers should be minimal.

One problem with selecting motion sensing alarm systems is that only one supplier was currently available, and that brand was designed for application on an IBM PC/XT. Requiring motion sensing alarm systems therefore, would have the undesirable side effect of requiring that specific hardware components be purchased.

Another type of security device available is one which is composed of 'plates' which are mounted on individual components of the computer system and to a permanent surface, a combination type lock, and a cable which ties the computer units and the permanent surface all together.

An advantage of this is that the same security system can be used on virtually any manufacturer's components, can be used for other components such as printers, and its cost is not prohibitive, [about $25.00].

Again, selecting a security device utilizing cables can have undesirable effects. In this case the total distance spanned by a cable connecting all components cannot exceed 2.5 feet. One popular micro-computer installation method is to have the monitor on a moveable arm above the desk, the keyboard on the desktop, and the cpu and additional expansion units mounted vertically at one side of the desk. In order to implement this, more than one security system would have to be purchased since the distance spanned would be more than the 2.5 feet maximum imposed by the cable length. Other aspects of this type of component arrangement are discussed in the Instructional Environment section.

In a typical micro computer installation, the addition of a security system at such a low cost per unit makes it well worth the investment. Both the motion sensor type and the method using a cable to connect components to a permanent fixture are recommended.

3. Storage Security

Along with providing security of the room, and individual components, the safeguarding against possible theft of other laboratory assets must be considered. These assets include diskettes, commercial software, paper and other miscellaneous items. Elaborate security

should not be necessary, and having lockable cabinets should be sufficient. The lockable cabinets should be partitioned to allow locking of individual parts of the cabinet. Under this method, access to the material within a particular section of the storage could depend on the user's needs.

Bulk amounts of paper and spare hardware components could remain locked up, while users would still have access to certain software. In addition, users requiring access to material of value could have keys or combinations granted them based on class registration.

The storage area will contain highly pilferable material. The control of this storage area, and access to it, is important and should be treated in a different manner than access to the laboratory room. A single person should be charged, as a collateral duty, with the responsibility for the items in the secure storage area. This person should ensure that combinations or locks are regularly changed, and that the list of persons afforded access is reviewed on a regular basis.

In summary, there must be full accountability for all of the high value components in both the storage area and the laboratory as a whole.

C. INFORMATION SECURITY

The computers comprising the laboratory will have the capability to both access another workstation [via network] and also to access, [and be accessed from] other computers outside the laboratory. This raises a concern about the security of data being passed via electronic means.

Today, modem programs give the user the capability of dialing a workstation from off campus and having the unattended modem automatically record the mail the user wanted to leave at a particular telephone number. There is a basic requirement for that to work: the modem and the computer must both be energized. Simply ensuring that all unused stations are deenergized will prevent unauthorized or undesired access into the network.

Should a workstation remain energized with a modem set up to receive electronic mail, it would be possible for an unauthorized user to gain access to the system, but the data on the system is expected to be limited to only that of other student terminal sessions. The result of such unauthorized access is that only miminal damage would be experienced.

In the network environment, when more than one workstation is 'on line', the users should be made aware that their data could be 'public', since each station

will have the ability to communicate with others on the system. The security of the data within the network is a function of the software used in establishing the network and, as such, is not a concern of facilities planning.

In order to utilize the laboratory, users will also have access to proprietary software. It will be difficult to establish controls to prevent the unauthorized copying of this material. Students should be reminded that no site license exits for the widespread distribution of these programs.

VI. SUMMARY

The Administrative Sciences Department at the Naval Postgraduate School is charged with, (among other things), providing military officers with exposure to computers and related technology. Inadequate present computer assets made it impossible to provide this exposure and provide a research environment for the students enrolled in the Information Systems Curriculum.

In 1985 a laboratory plan began to take shape which, when completed, would enable the Administration Sciences Department to more adequately meet their rising computer needs. The facilities planning contained in this thesis was considered an integral part in laboratory construction.

While several considerations were necessary in planning the laboratory facility, efforts were made to achieve a layout which would provide the desired research and instructional environment, minimize implementation costs, and at the same time, retain flexibility in the use of laboratory components.

In some instances, practical aspects of laboratory design made it necessary to accept less than perfect conditions. For example, while the optimum lighting arrangement required various light intensities, depending on

what was being lighted, room constraints made it more realistic to set a constant light intensity throughout the laboratory.

The shape of the room chosen was not an impediment. The 'L' shaped room was optimized by putting storage cabinets, a desktop mounted printer and two smaller printers in the space created by the 'L' shaped area. The design also provides an airy atmosphere.

Laboratory components are an important part of overall laboratory design and this is not limited to just the computers to be used. Many vendors manufacture elaborate computer workstations which they claim to be 'perfect' for microcomputer use. However in a high use environment, simplicity of design is a desired attirbute rather than a hinderance. Workstations with sliding trays for keyboards become a maintenance problem rather than a student convenience.

While it would have been nice to select furniture which had vertically mounted central processing units, the affect on the vendors warranty precluded this.

To be able to assess the physical requirements of the laboratory environment such as lighting, heating, cooling etc., the designers must approach the problem from a technical viewpoint. The designer cannot afford to make general estimates of requirements and conditions based, not

on facts, but on his personal opinions. In this thesis, attention has been devoted to these items and the authors are satisfied that with the recommendations contained within, the laboratory will be an effective place for both instruction and research.

Security of a laboratory containing expensive equipment becomes a concern regardless of the calibre of people using the facility. The installation of adequate security devices ranging from locks on the door, to motion sensing devices on individual components, are well worth the investment.

With final implementation of the laboratory described herein, the Administrative Sciences Department will have a microcomputer laboratory which will better enable them to carry out their mission of instructing students, and also provide a state-of-the-art facility for computer-related research. In addition, it will be able to serve as a model for other microcomputer laboratory construction projects within the Department of the Navy.

APPENDIX A : REQUIRED ELECTRICAL POWER

Each workstation in the laboratory consists of at least two separate components, a CPU and a monitor or display unit. In addition, some stations may include a printer. In calculating the power required for these loads, the most conservative (highest) estimate was used for each unit to allow a margin of safety in the wiring design. This estimate came to 4 amperes per workstation at 115 volts AC. With a total of 25 workstations this resulted in a total power requirement of 100 amperes.

APPENDIX B : ROOM HEAT LOAD CALCULATIONS

The introduction of microcomputers into the classroom caused a significant new factor to be added to the room's heat gain calculation.

The computers are the largest source of heat and the calculation of their heat load follows. The 3.4 conversion factor (CF) is used in ventilation engineering to change appliance wattage to sensible heat. An average value of 100 watts was used per unit (far below the peak value used for wiring requirements but typical of the machines in use).

25 units x 100 watts/unit x 3.4 CF = 8500 BTU/hour.

The second largest factor is the body heat loss from the 25 people expected to use the rooms. This loss is estimated at 250 BTU/hour.

25 persons x 250 BTU/hour-person = 6250 BTU/hour.

The final factor is the contribution of room lighting figured at the existing level of about 800 lux, which is 2 watts per square foot.

2 watts/sq ft x 600 sq ft x 3.4 CF = 4080 BTU/hour

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for a total of 18830 BTU/hour

Using a conversion factor of 1/22 for the conversion of BTU/hour to cubic feet per minute (cfm) of required

ventilation yields 856 cfm required, which is well under the existing air flow.

The rules-of-thumb used in these calculations are found in Reference 6.

APPENDIX C: FIGURES

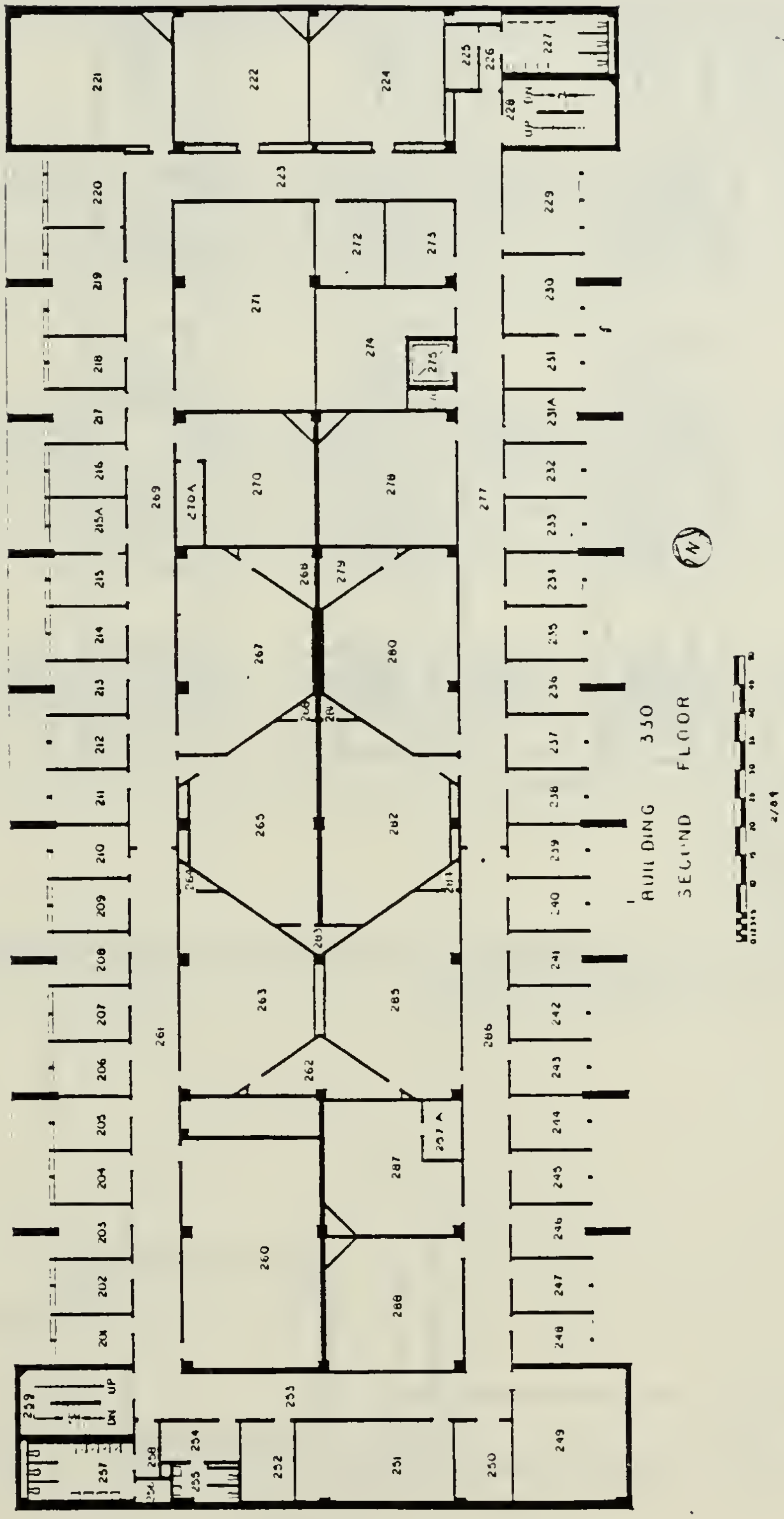

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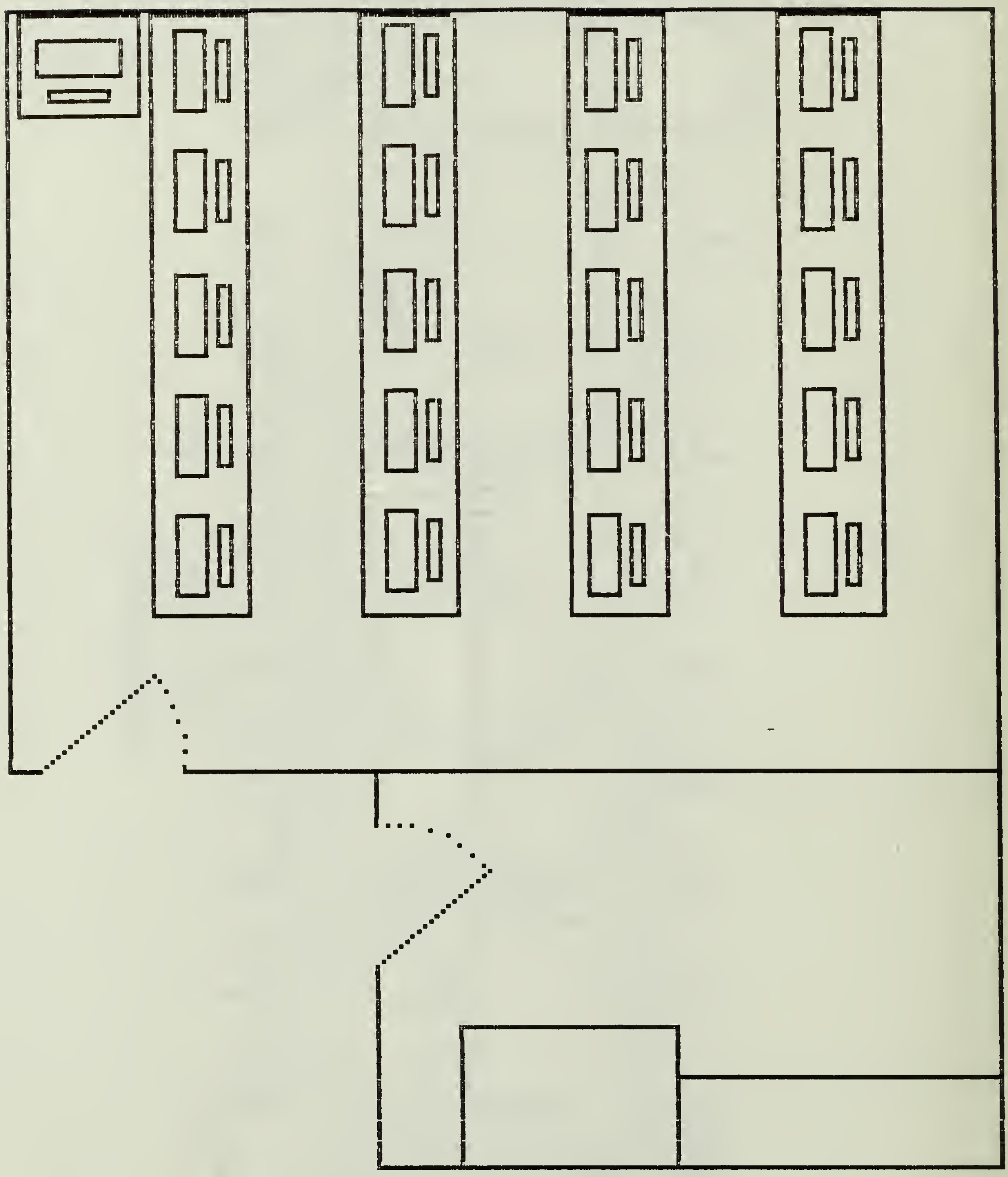
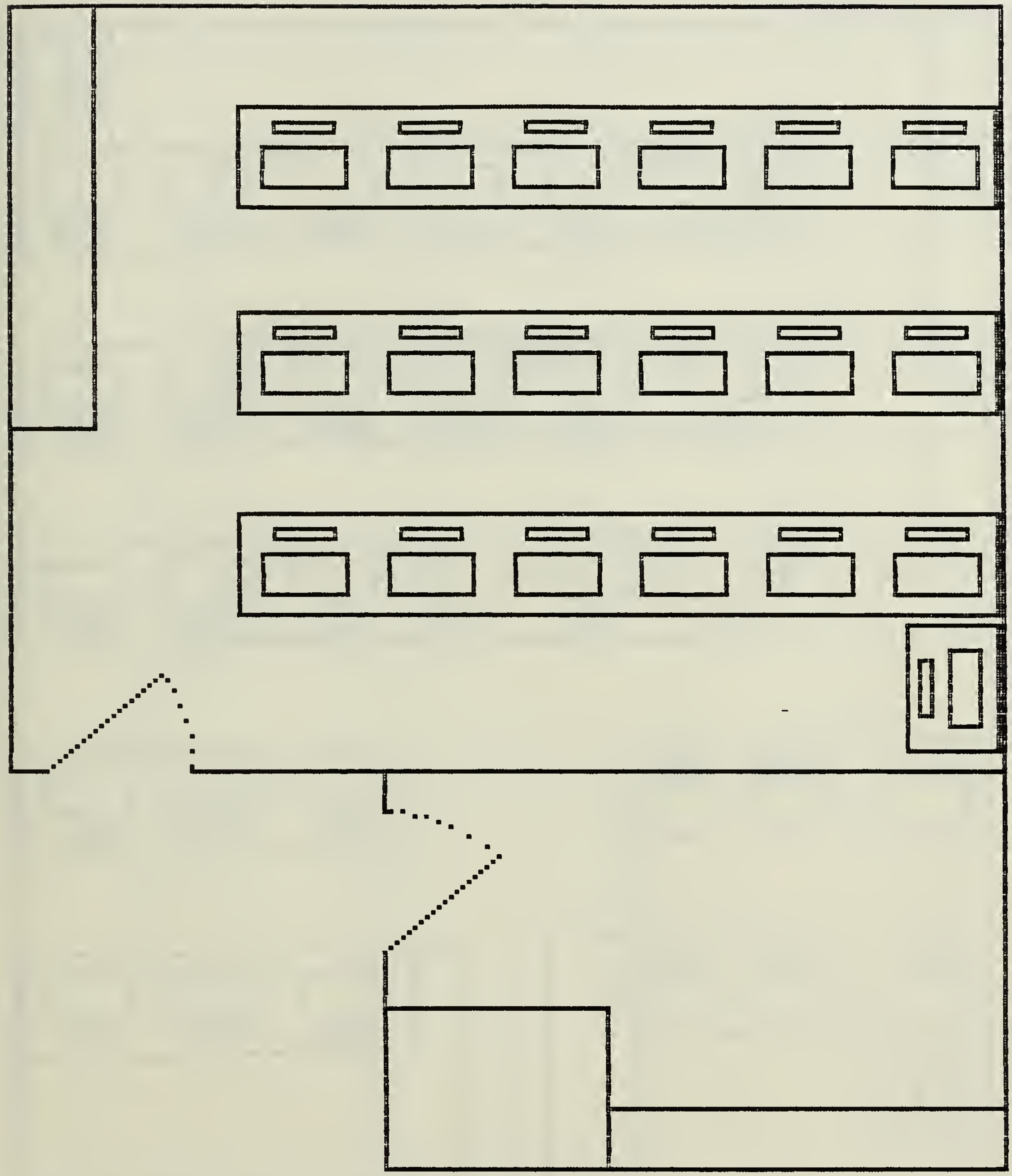
Figure 1



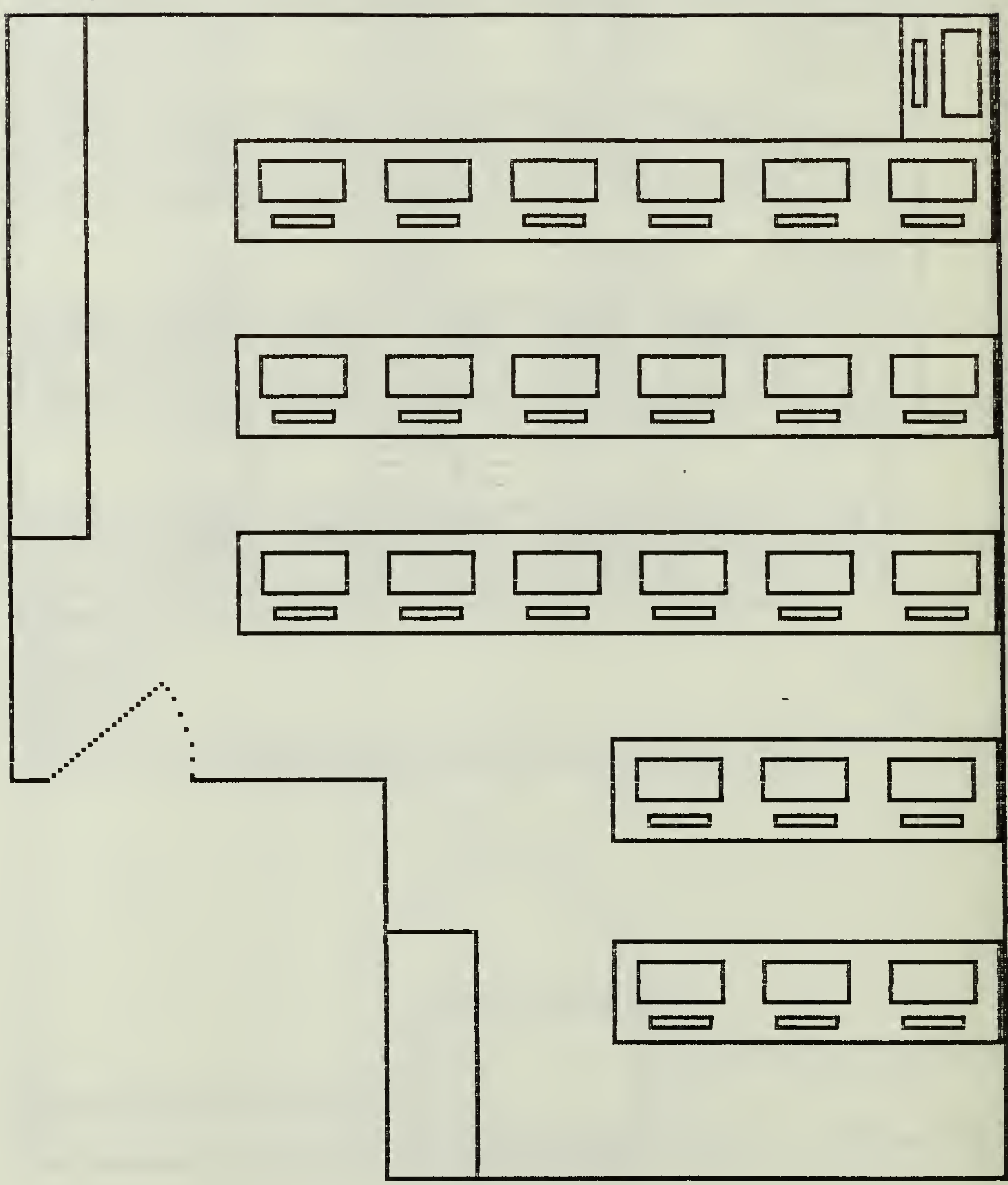
Layout 1

Figure 2



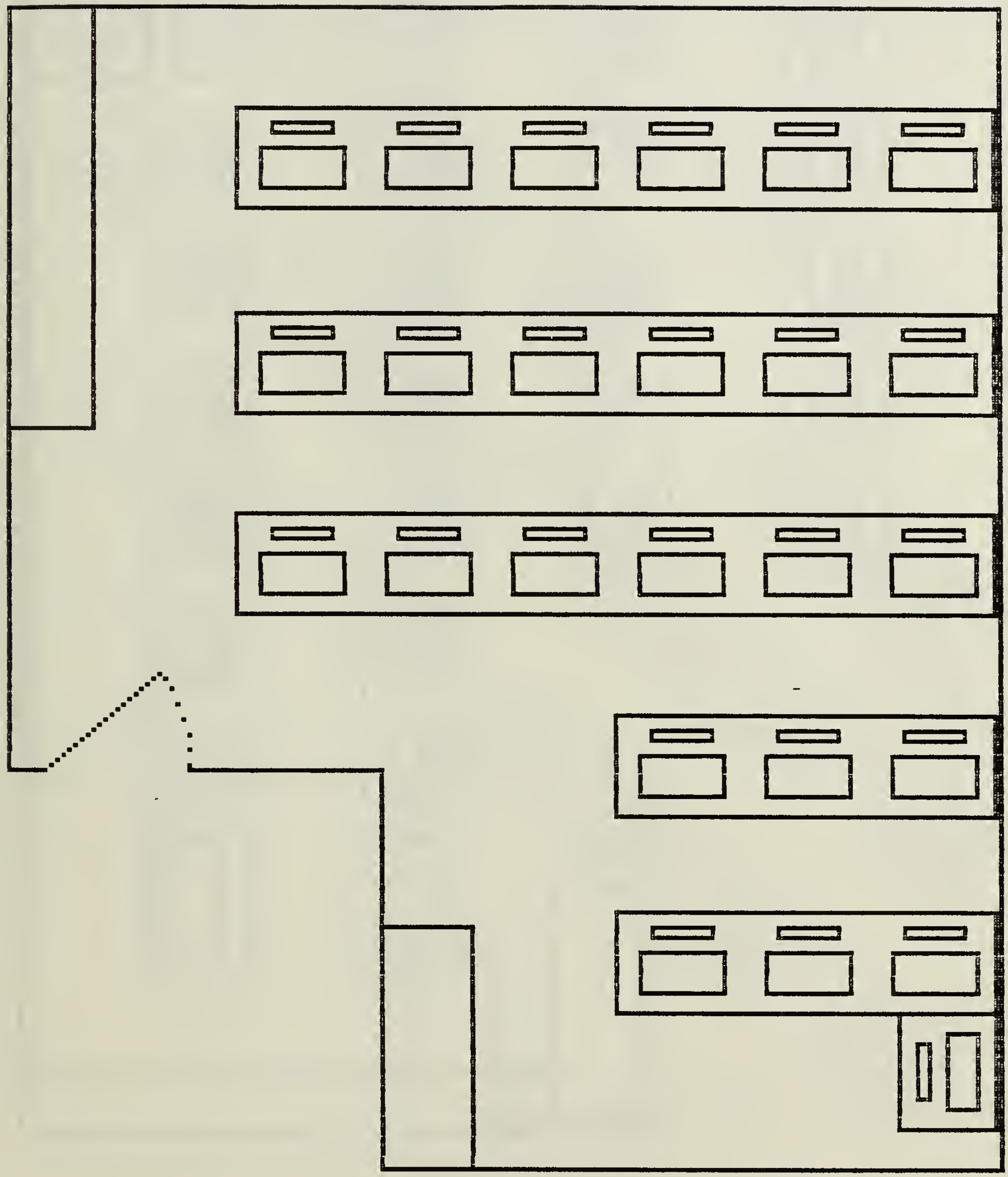
Layout 2

Figure 3



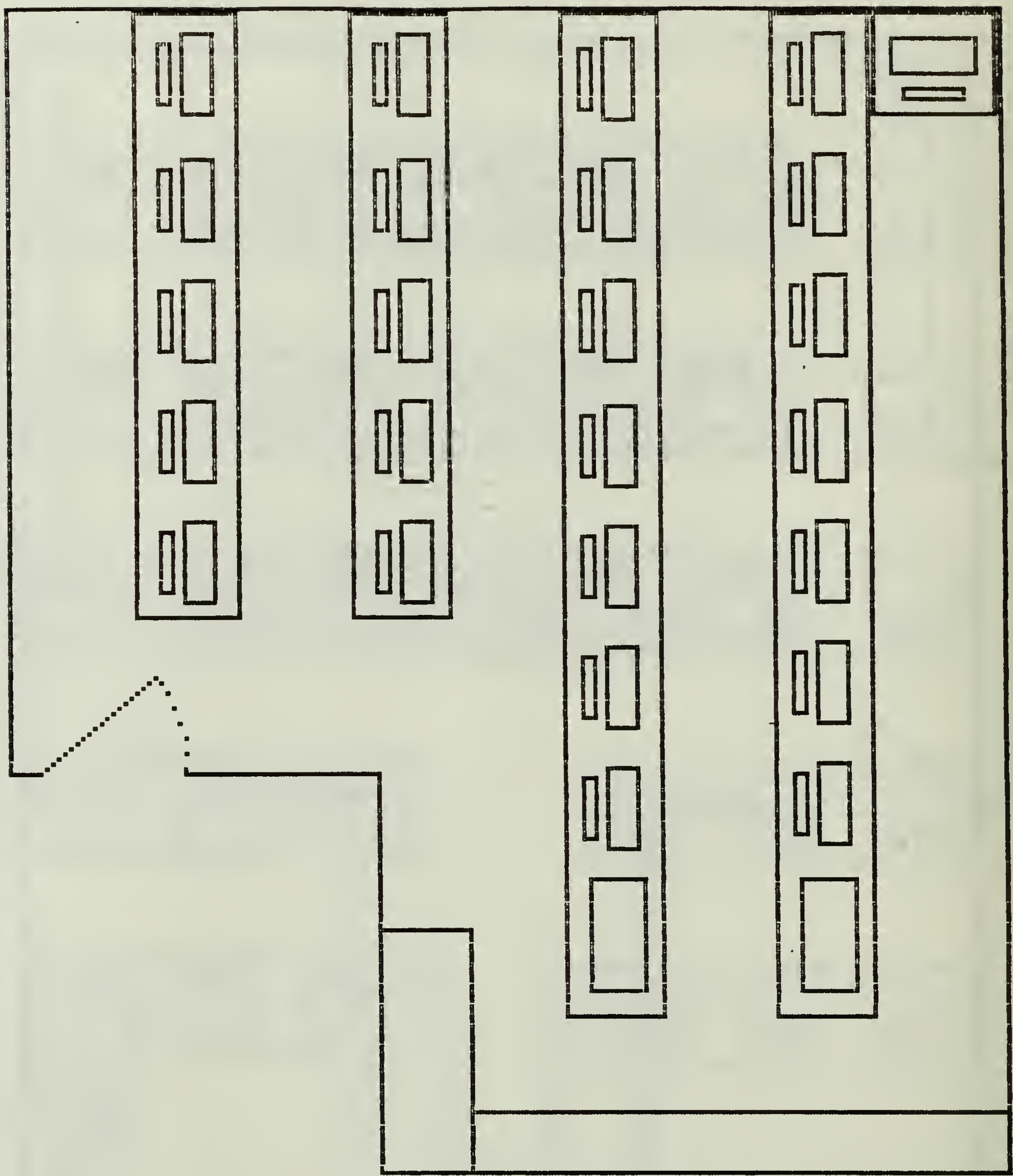
Layout 3

Figure 4



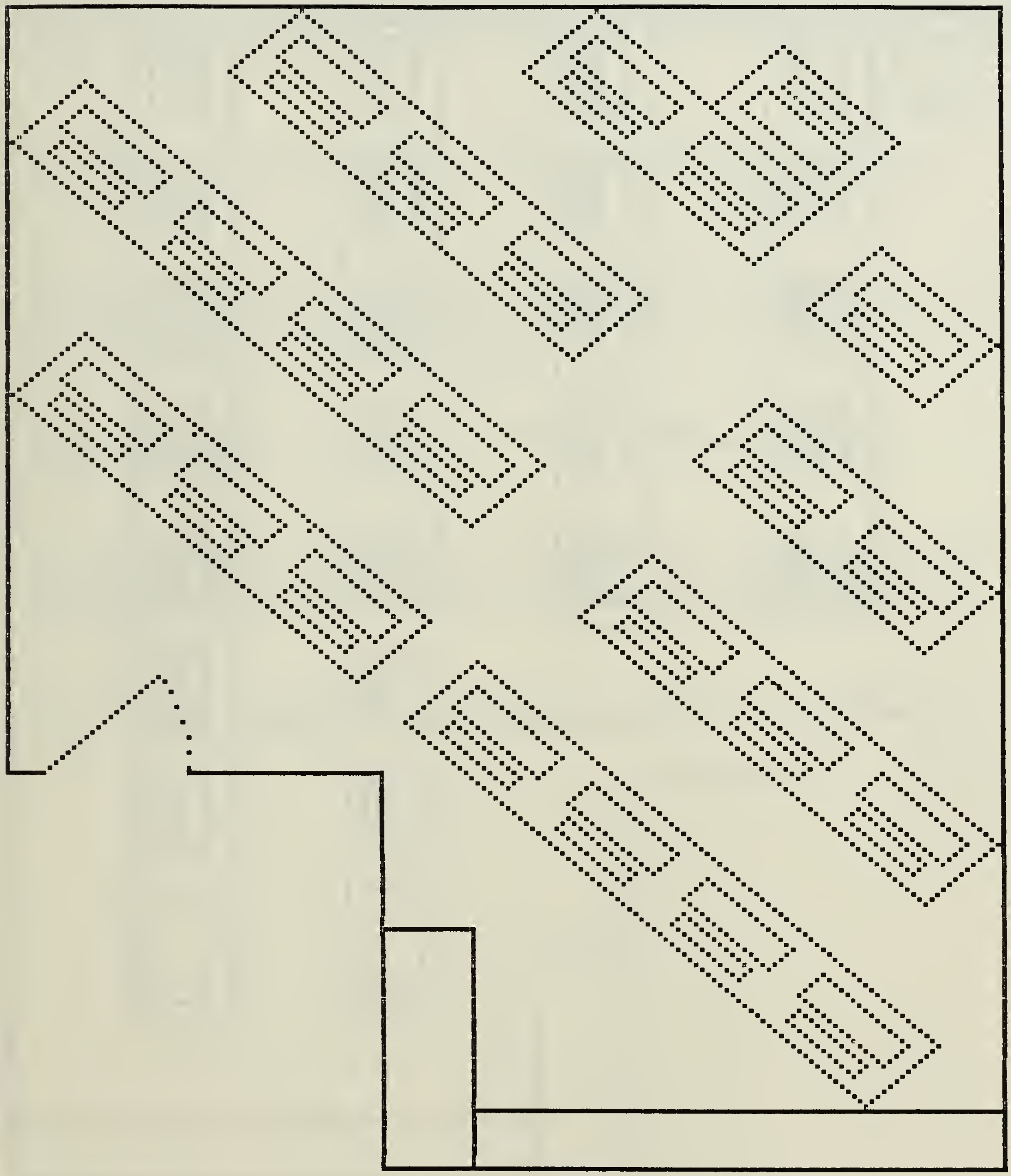
Layout 4

Figure 5



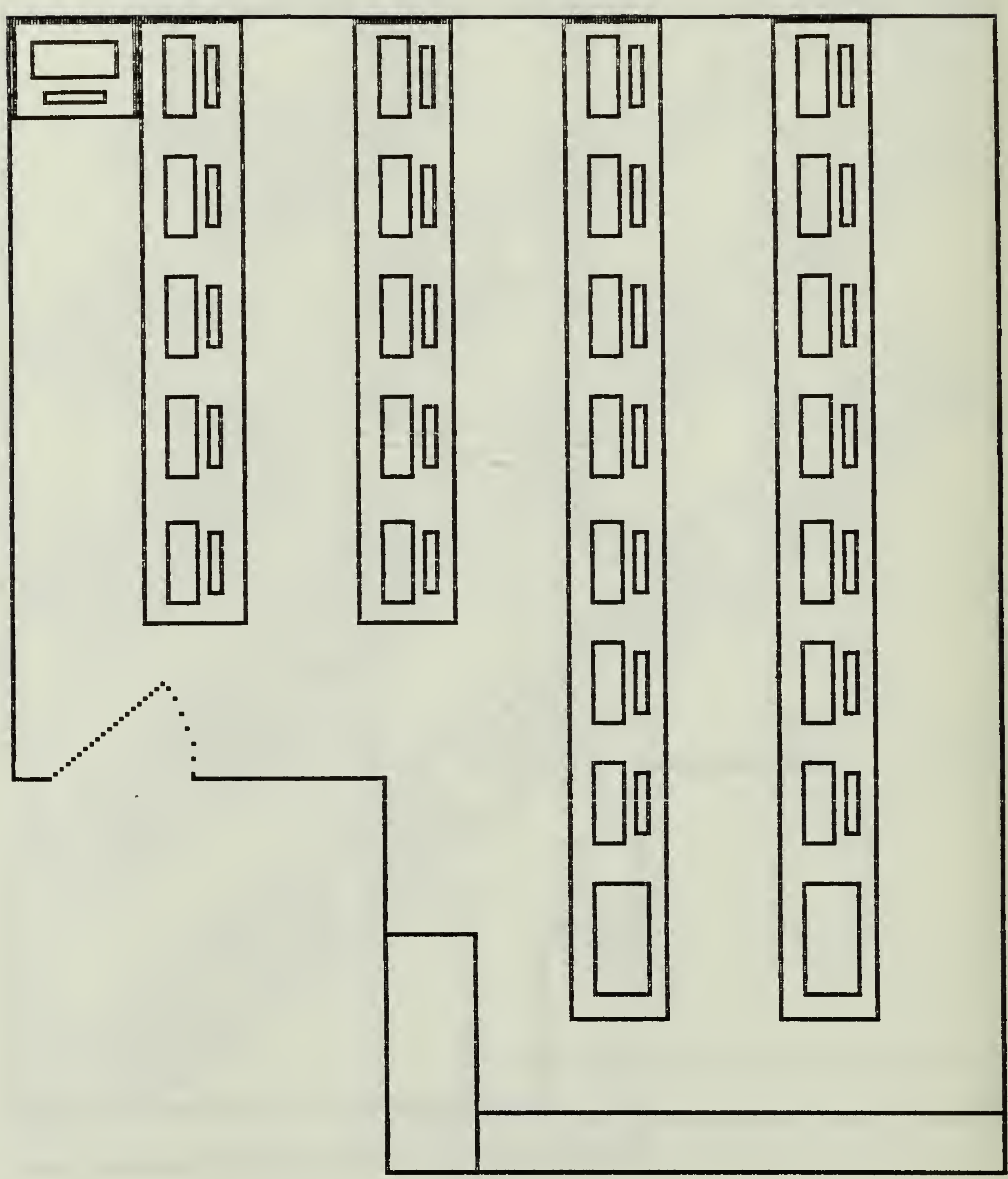
Layout 5

Figure 6



Layout 6

Figure 7



Layout 7

Figure 8

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